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Exploring the Value at Risk of Oil-exporting Country Portfolio: An Empirical Analysis from the FSU Region

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Abstract

In the perspective of oil-importers, this paper considers an extension of the Value at Risk approach incorporated with time-varying conditional volatility model to trace the actual dynamic risk of regional oil-importing portfolio caused by the country risk volatility. With an application to oil economies in the Former Soviet Union (FSU) region, empirical results show that the country portfolio risk of oil-imports and country risk volatility in the FSU region has more significant influence on China's oil-importing risk than that on EU's.

Keyword: Country risk; Value at Risk; Portfolio; BEKK model; Cornish-Fisher

1. Introduction

Former Soviet Union (FSU) region has emerged as an important international energy supplier besides the OPEC countries. The rich oil and gas resources have attracted a large number of cooperation with oil-importing countries, especially China and European Union (EU) countries who are trying to diversify their sourcing of crude oil imports to reduce the dependence on the Middle East and to mitigate their oil-importing risk [1].

Regarding to evaluating the oil-importing risk quantitatively, Wu et al. (2007) [2] adopted the risk weight coefficient of oil-exporting regions calculated through AHP approach in the perspective of China's oil-importing security. Gupta (2008) [3] assessed geopolitical oil market concentration risk of 26 net oil-importing countries by adjusting the market shares for political risk ratings in the oil-exporting countries. In a related work, He et al. (2009) [4] proposed an OICR Index incorporated with the country risk of 17 major oil-producing countries to evaluate the oil-importing risk. Within these literatures, the risk weights of oil economies are static, and conducted by taking some special risk as a proxy of the whole risk of a given oil economy, some even conducted on subjective judgment.

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Thus, these methods above bring a practical problem: how to quantize the dynamic oil-importing risk brought by the whole risk volatility of oil economies?

Much attention has been paid to techniques of modeling country risk and analyzing its properties [5, 6]. Recently, Hoti et al. (2007) [7] adopted the MGARCH model to investigate the relationship of the country risk and the island tourism economies. Li et al. (2009) [8] verified the dynamic correlations and spillover effects of country risk between Russia and Kazakhstan using BEKK model. These empirical studies proved the applicability of the GARCH models when applied to analyze the country risk, and indicated that it is more reasonable to consider the risk interaction between countries when calculating country portfolio risk.

On the background of energy security, taking the FSU region as a whole, Sun et al. (2009) [9] identified the risk-return spectrum of oil imports from the FSU region. Further, taking country risk into account, the primary purpose of this paper is to trace the actual dynamic country portfolio risk of oil imports caused by the regional country risk volatilities. With an application to the FSU region, a modified Value at Risk (*VaR*) approach incorporated with time-varying conditional volatility model is adopted. The plan of this paper is as follows. The econometric model is described in Section 2. Section 3 analyzes the empirical results, and some concluding remarks and future work are given in section 4.

2. Econometric model specification

According to UNcomtrade database (2008), for EU and China, oil imports in the FSU region almost come from Russia and Kazakhstan. Thus, when we investigate the country risk portfolio, Russia and Kazakhstan are chosen to be the proxy of FSU oil economies, and to be the component of the country portfolio of oil imports. In this paper, we analyze the country risk of Russia, Kazakhstan using the International Country Risk Guide (ICRG) ratings from Dec. 1998 to Aug. 2008 considering the availability of the data. As country risk ratings can be treated as financial indexes, country risk return series were generated using

$$crr_{i,t} = 100 \times [\log(cr_{i,t}) - \log(cr_{i,t-1})], t = 1, 2, \ldots, T, \tag{1}$$

where, $cr_{i,t}, i = (1,2)$ is the country risk rating, and $crr_{i,t}, i = (1,2)$ is the logarithmic return of Russia and Kazakhstan.

Step 1：Following Asai and McAleer (2008) [10], let the country risk returns on 2 financial assets be given by $crr_{i,t} = \mu_{i,t} + \varepsilon_{i,t}, i = 1,2$ or $crr_t = \mu_t + \varepsilon_t$. The return of the country portfolio risk consisting of $crr_{1,t}, crr_{2,t}$, is denoted as $prr_{Pi,t} = \omega' crr_t + \omega' \varepsilon_t$, where $\omega = (\omega_1, \omega_2)'$ denotes the portfolio weights, satisfying $\omega_1 + \omega_2 = 1$. Considering the ratio of oil imports from Russia and the ratio from Kazakhstan, the country portfolios are conducted with weights $\omega_C = (0.77, 0.23)'$ for China and $\omega_E = (0.87, 0.13)'$ for EU, denoted as $prr_{Ch,t}$ and $prr_{EU,t}$, respectively.

Step 2：Considering that modeling $prr_{Pi,t}$ as a simple univariate process may lose valuable information, multivariate conditional volatility model in the framework of the Multivariate GARCH is used to estimate the conditional covariance matrix of country risk returns of Russia and Kazakhstan. Firstly, VAR process is used to filter country risk returns and the residual errors $(\varepsilon_1, \varepsilon_2)$ is obtained. Then, BEKK model of Engle and Kroner (1995) [11] was proposed in order to reduce the computational burden of a Vech-Multivariate GARCH [12], and is given by

$$\begin{cases} \varepsilon_t \left| I_{t-1} \sim (\varepsilon_1, \varepsilon_2)' : N(0, H_t) \right. \\ H_t = C'C + \sum_{i=1}^{q} A_i' \varepsilon_{t-i} \varepsilon_{t-i}' A + \sum_{i=1}^{p} B_i' H_{t-i} B \end{cases} \tag{2}$$

where, $H_t = [h_{ij,t}], i, j = 1,2$ is the conditional covariance matrix of country risk returns, $crr_{1,t}$ and $crr_{2,t}$. The BEKK-GARCH (1, 1) model under a conditional normal distribution is chosen to estimate parameters, and the dynamic *VaR* with normal distribution is calculated as:

$$VaR_{P,t} = \omega' u_t - Z_{P,q} \sqrt{\omega_1^2 h_{11,t} + \omega_2^2 h_{22,t} + 2\omega_1 \omega_2 h_{12,t}} \tag{3}$$

and denoted as $nVaR_{P,t}$.

Step 3：The conventional VaR assumes that returns follow a normal or conditional normal distribution [13]. Considering the excess kurtosis and negative skewness of country risk returns, a modified *VaR*, which was provided on the base of the Cornish-Fisher expansion [14, 15], is used to measure the dynamic risk of country portfolios, $prr_{Ch,t}$ and $prr_{EU,t}$. Then, the modified *VaR* measure is calculated as follows:

$$VaR_{P,t} = \omega' u_t - Z_{CF}^{q} \sqrt{(\omega_1^2 h_{11,t} + \omega_2^2 h_{22,t} + 2\omega_1 \omega_2 h_{12,t})} \tag{4}$$

and denoted as $mVaR_{P,t}$,and

$$z_{CF}^{q} = z_N^q + \frac{1}{6}(z_N^{q\,2} - 1)\cdot s + \frac{1}{24}(z_N^{q\,3} - 3z_N^q)\cdot k - \frac{1}{36}(2z_N^{q\,3} - 5z_N^q)\cdot s^2 \tag{5}$$

where z_N^q is q% confidence quantile of standard normal distribution, s is sample skewness, and k is sample kurtosis.

3. Empirical results

In order to display the relationship visually, the conditional variances (shown as Ht in Fig. 1), displaying significant volatility clustering, and the time-varying correlation coefficients are given by $R_t = \rho_t = h_{12,t} \big/ (\sqrt{h_{11,t}}\sqrt{h_{22,t}})$. The correlation coefficients vary significantly over time ranging from -0.383 to 0.838 with the mean 0.318 and median 0.309, mostly higher than the unconditional correlation coefficient 0.19. This suggests that Russia and Kazakhstan are closely related in terms of the shocks to their country risks.

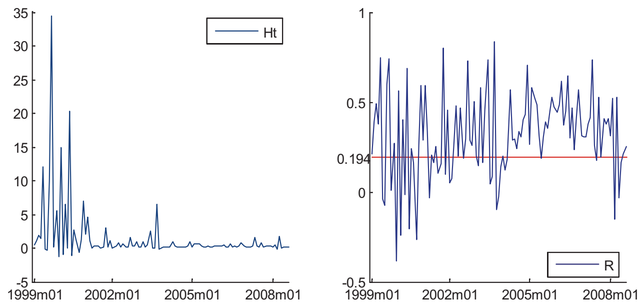

Fig. 1 Dynamic correlation between Russia and Kazakhstan

Based on the estimation of BEKK model, *mVaR* and *nVaR* values are calculated at 97.5%, 99% confidence level. When the actual return is smaller than the *VaR* value, violations occur. If N violations in a sample of size T, $\delta = m/T$ is the ratio of violations. The basic test of *VaR* model accuracy is conducted by comparing the ratio of violations at $1-\alpha\%$ confidence level with the significance level $\alpha\%$. For example, *VaR* calculated assuming a 95% confidence level should include 95% of observations, leading to violations of 5% of the time. The probability of δ, under the null hypothesis, is given by $\Pr(N) = C_N^T (\hat{\delta})^N (1-\delta)^{T-N}$, where $\hat{\delta}$ is the desired ratio of violations. Christoffersen (1998) [16] referred to this test as a test of Unconditional Coverage (UC) and used *LR* statistic for testing whether δ is equal to $\hat{\delta}$. The *LR* statistic is given by:

$$LR = 2[\log(\hat{\delta}^N (1-\delta)^{T-N}) - \log(\delta^N (1-\delta)^{T-N})] \tag{6}$$

and asymptotically distributed as $\chi^2(1)$ under the null hypothesis of correct UC. According to the *LR* statistics of back testing, the *mVaR and nVaR* values at 97.5%, 99% confidence level are accepted.

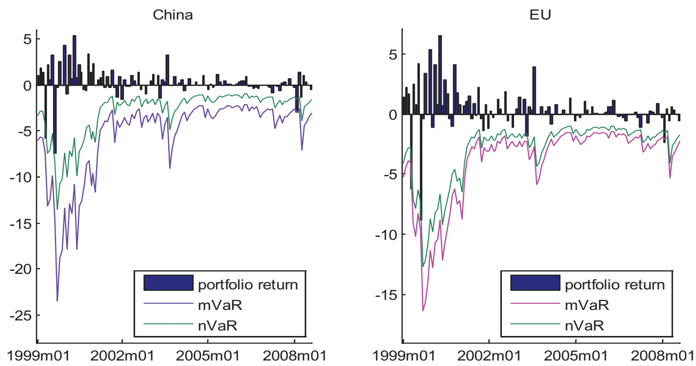

Fig. 2 *nVaR* and *mVaR* at 99% confidence levels

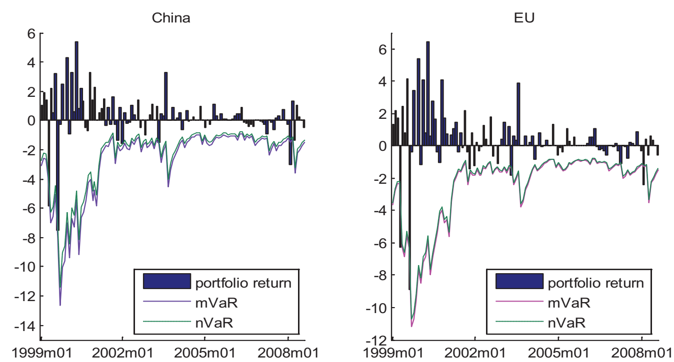

Fig. 3 *nVaR* and *mVaR* at 97.5% confidence levels

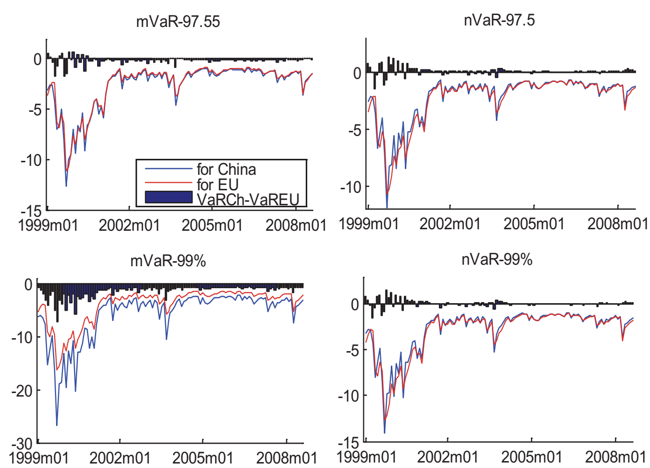

Fig. 4 *VaR* values for China and EU at 99%, 97.5% confidence levels

As shown in Fig. 2-4, whether at 99% or at 97.5% confidence level, nearly 65 percent of *nVaR* values for EU are smaller than that for China, which means that with the assumption that the returns of country risk portfolio satisfy normal distribution, risk of country portfolio for EU is mostly larger than that for China. In other words, in the face of country risk volatility in the FSU, EU bears larger oil-importing risk. However, about 88 percent of *mVaR* for China at 97.5% confidence level, and all at 99% confidence, are smaller than that for EU at corresponding confidence level. Thus, it is concluded that when the more distributional characteristics (skewness and kurtosis) are concerned, China faces larger oil-importing risk caused by country risk volatility in the FSU.

4. Conclusions

This paper considers an extension of the Value at Risk model incorporated with time-varying conditional volatility model to trace the actual dynamic risk of regional oil-importing portfolio caused by the country risk volatility, with an application to the FSU oil economies: Russia and Kazakhstan. Empirical results show that *mVaR* is a better method to dynamically describe the country portfolio risk of oil-exporting countries in this region, and the country portfolio risk has more significant influence on China's oil-importing risk.

On a practical level, our future work in this area will focus on these questions: How will the country portfolio *VaR* change, if other countries (such as Azerbaijan) are considered, or if some oil-related factors (such as oil price) are introduced into the model? This type of risk analysis would be useful to evaluate the relative status of energy security between different oil-importers in a strategic perspective, and be useful to identify the regional oil market risk caused by the country risk volatility.

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